Name:_____________________________ Date:____________

The Hudson Valley Rocks!

We live in a beautiful place. Tens of millions of people travel from around the world to visit the Hudson Valley each year. But what is the Hudson Valley *made* of, and what does this have to do with the mountains, streams, and valleys that we enjoy today?

Pre-Lab or Previous Evening's Homework:

Read the article "Rocks serve as snapshot of valley's timeline" by Jill S. Schneiderman. As you read the article underline or highlight the names of any rocks she mentions. When you are finished, answer the following questions below.

1) What is the difference between bedrock and sediment? (You may want to use the textbook to help you with this question.)

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2) What are the three TYPES of rocks that can be found scattered across the Hudson Valley?

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3) What are the differences among the three types of rocks you named in question #2?

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Research and Identification

A. Look at the Hudson Highlands Segment of the Geologic Map of New York State. Identify where the Hudson Highlands are located on the map. (They are just south of Beacon and run south to Peekskill.)

Hudson Highlands Segment of the Geologic Map of New York State

10 HUDSON HIGHLANDS

Rocks of Middle Proterozic Age (1.3-1.0 billion years old)

- Leucogranitic gneiss (lacks dark minerals)
- Interlayered hornblende granitic gneiss and amphibolite
- Hornblende granitic gneiss
- Biotite granitic gneiss, hornblende granitic gneiss
- Pyroxene-hornblende granitic gneiss (charnockite)
- Garnet-quartz-feldspar gneiss, minor marble, amphibolite, rusty gneiss
- Rusty and gray biotite-quartz-feldspar gneiss with variable amounts of garnet, sillimanite, cordierite, graphite, sulfide; minor marble and calcsilicate rock
- Biotite-quartz-plagioclase gneiss with subordinate biotite granitic gneiss, amphibolite, calcsilicate rock
- Garnet-biotite-quartz-feldspar gneiss, quartzite, quartz-feldspar gneiss, calcsilicate rock
- Calcitic and dolomitic marble, calcsilicate rock, interlayered gneisses

1) Name at least three kinds of metamorphic rocks that can be found in the Hudson Highlands area around Cold Spring, Garrison, West Point, and Highland Falls. Don't be fooled by the mineral names preceding the rock name.

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Now locate the Hudson Highlands on the Generalized Bedrock Geology of New York State map found on page 3 of your reference tables.

2) What happened to these rocks 1,000 mya (*m*illion *y*ears *a*go)?

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3) To find out more about your answer to question 2, look at page 7 of your reference tables and find the kinds of rocks you listed above. How did those rocks get to be as they are?

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4) Using page 7 of your reference tables, see if you can identify which rock sample is the "marble-cake gneiss" mentioned in the article you read.

Conclusion: Write <u>one complete sentence</u> describing what you have learned about the rocks of the Hudson Highlands.

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B. Refer back to the article you read to answer the questions below.

5) Which two kinds of rocks are found north of the Highlands?

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6) What do these rocks have in common?

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Refer to page 7 of your reference tables.

7) One of the rocks that you listed above is "chemically and/or organically formed. What does this mean and which rock does it apply to?

8) The rocks of the Poughkeepsie area and the area north of the Hudson Highlands were laid down between 435 and 500 mya. Using the Geologic History Table in your reference tables infer what kind of environment existed in New York State at this time?

9) Why is water so important to the creation of both of the rocks?

10) Using page 7 of your reference tables, see if you can identify which rock samples are the dolostone and shale mentioned in the article you read.

Conclusion: Write one complete sentence describing what you have learned about the rocks north of the Hudson Highlands and in the Poughkeepsie area.

C. The Taconic Mountains lie just east of the Hudson River, while the Catskill Mountains lie just to the West. Even though both mountain ranges (the Catskills are actually an eroded plateau) lie geographically close to one another, they are very different in rock composition and thus differ in how they were formed. Let's focus on the Taconic Mountains first.

11) Referring back to the article, list the kinds of rocks one can find in the Taconic Mountains. *Note: sillimanite needles and staurolite crystals are found within these other rocks.*

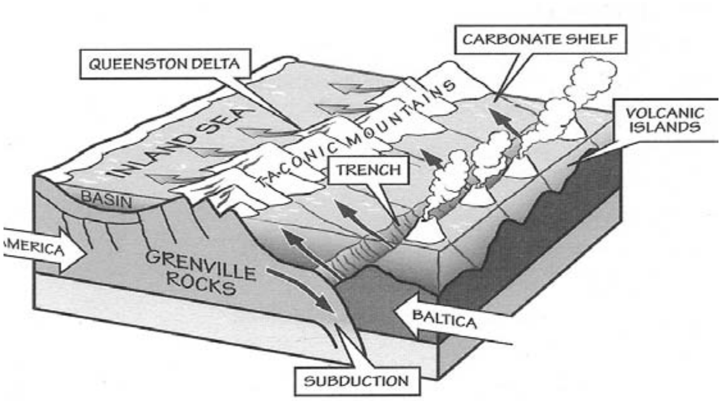

Figure 1.8: Volcanic islands formed where the plates were forced together as the Iapetus Ocean closed. The compression crumpled the crust to form the Taconic Mountains and a shallow inland sea. Figure by J. Houghton.

12) Which rock type do these rocks fall under? (Refer to your reference tables.)

13) The diagram at left illustrates what occurred during the Taconic Orogeny. Referring back to the article, what is an Orogeny?

14) Now that you know what types of rocks make up the Taconics and what an orogeny is, use the diagram above to describe what happened to make the rocks what they are. In your answer you must use the following words or phrases: Plate boundary, collision, metamorphism, and subduction.

15) What parent rocks likely existed in the area before the Taconic Orogeny?

16) Using page 7 of your reference tables, see if you can identify which rock samples are the slate and schist mentioned in the article you read.

Conclusion: Write <u>one complete sentence</u> describing what you have learned about the rocks of the Taconic Mountains.

D. Refer back to the article you read to answer the questions below.

17) What were the three types of rocks that were created by sediments shed from the Acadian Mountains?

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18) What do these rocks have in common?

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19) Using the Rock Cycle in Earth's Crust diagram in your reference tables, list the steps a metamorphic rock would likely go through to become a sedimentary rock. Be precise.

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20) Why would the sediment build up in the Catskill Delta be two miles thick? (Hint: What is a delta? How long did the Acadian Orogeny last?)

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21) The Catskill Mountains were formed as an *indirect* result of the Acadian Orogeny that happened 345 million years ago or later. In fact, the Acadian Mountains existed east of the Taconics and Hudson Highlands while today's Catskills lie far to the west. Using the diagram on the next page and the article, try to figure out how the creation of one mountain would in turn create the material for another. In your response you must use the following words: Acadian Mountains, sediments, deposition, erosion, delta, and Catskill Mountains.

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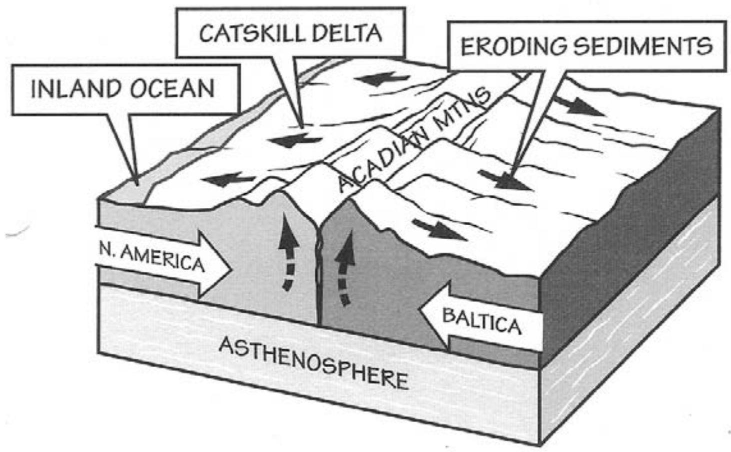

Figure 1.14: North America and Baltica collided finally in the mid-Devonian, crumpling the crust to form the Acadian Mountains. Sediments eroded from the highlands formed the Catskill delta. Figure by J. Houghton.

22) Using page 7 of your reference tables, see if you can identify which rock samples are the conglomerate and sandstone mentioned in the article you read.

Conclusion: Write <u>one complete sentence</u> describing what you have learned about the rocks of the Catskill Mountains.

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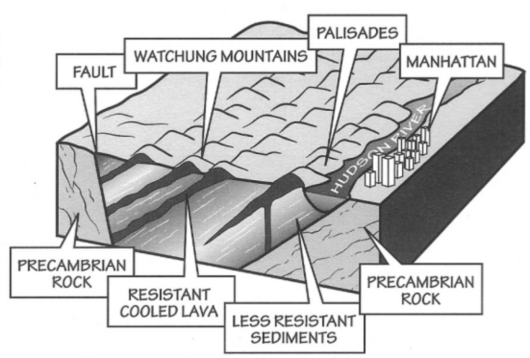
<u>E.</u> In the article, the author mentions that magma was injected into sediments that collected in rift valleys that formed when landmasses began to tear apart. This magma would eventually cool, harden, and form what are now called the Palisades, a ridge of rock bordering the Hudson River just north of New York City. See the diagram below as a reference.

Figure: 1.22: The softer sediments of the Newark Rift basin were quickly worn away, forming valleys between the more resistant ridges of hardened lava flows. Figure by J. Houghton.



23) What type of rock makes up the Palisades?

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24) The rocks of the Palisades are composed primarily of plagioclase feldspar, pyroxene, and olivine along with small amounts of other minerals. The grain size of the rocks tends to be less than 1 mm and they are non-vesicular. What kind of rock makes up a portion of the Palisades?

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25) Using your reference tables, see if you can identify which rock sample is the kind that makes up part of the Palisades.

Conclusion: Write <u>one complete sentence</u> describing what you have learned about the rocks of the Palisades.

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F. 40,000 years ago a glacier began advancing across much of northern North America. In time it would retreat, reshaping the land in the process. This time period is known as an Ice Age.

26) Name two pieces of evidence a glacier would have left as it advanced/retreated across the land.

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27) What kind of sediment sizes does a glacier deposit as it drops the material it is carrying in and on top of the ice?

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28) Describe the shape of the valleys the glaciers would have carved as they moved across the land. Many of the small valleys within the greater Hudson Valley have this shape.

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29) Identify which rock sample would be the kind deposited by the glaciers as the ice moved across the land. (Hint: Most of Long Island is made of this kind of rock sample.)

Conclusion: Write <u>one complete sentence</u> describing what you have learned about the rocks left behind by the glaciers.

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30) So why does all of this talk about Hudson Valley rocks matter? Rocks play many roles in our lives that we take for granted and don't initially recognize. In her article, Jill Schneiderman mentions some of the industries that arose in the Hudson Valley to exploit the rich geologic resources that exist. Many of the rocks you researched above are exported to local communities and even further abroad. In the space below, list at least three examples of rocks found in the Hudson Valley that are used in industry and for which industry they are used.

Image credits

Figures 1.8, 1.14, and 1.22 used with permission from Ansley, J. E. 2000. The Teacher-Friendly Guide to the Geology of the Northeastern U.S. Paleontological Research Institution, Ithaca, NY.

Rock Identification Worksheet

Name: ______________________ Period: ____________________

Rock Name (Location)	***Identification Number***
Gneiss (Hudson Highlands)	
Dolostone (Poughkeepsie)	
Shale (Poughkeepsie)	
Slate (Taconics)	
Schist (Taconics)	
Conglomerate (Catskills)	
Sandstone (Catskills)	
Basalt (Palisades)	
Glacial Till (Hudson Valley)	

Rocks serve as snapshot of valley's timeline

By Jill S. Schneiderman
For the Poughkeepsie Journal

The names Alexander Hamilton, Aaron Burr, George Washington, Benedict Arnold, Billy the Kid, Thomas Cole, Frederic Church, Edna St. Vincent Millay and Pete Seeger conjure up our region's rich historic past.

But what of its prehistory? Rocks along both banks of the Hudson River and throughout its valley and adjacent mountains record a long and complex geologic history.

On this land, human history has played out. Much of the geologic drama occurred in prolonged pulses of activity during the Paleozoic, Mesozoic and Cenozoic Eras — 570 million years, but only the latest 13 percent of geologic time.

Though remarkable in the geologic scheme of things — uplift of Himalayan-sized mountains, spreading of inland seas of which there are no comparisons today save perhaps Canada's Hudson's Bay, tearing of continental crust, and burial by mile-thick ice — we read the record of these events in subtle clues from our area's rocks.

Compared to human events over the last 400 years and those that will transpire in the next millennium, geology seems to provide a record of change whose pace requires patience.

As historians, geologists think from the past to the present — and so first we marvel at rocks of the Hudson Highlands. They begin near Anthony's Nose, at the eastern edge of the Bear Mountain Bridge on the border of Westchester and Putnam counties. (It is named, according to legend, for the nose of Peter Stuyvesant's trumpeter, Anthony Corlaer, who had a nose "of vast lusty size strutting boldly from his countenance like a mountain of Golconda". Golgonda, India, the center of the diamond trade, denoted excess.)

The Highlands then run north to Breakneck and Storm King mountains, and they consist of more than 1 billion-year-old, coarsely crystalline granites and magnificent marble-cake gneisses.

They are the bedrock of our area, the core of our continent, metamorphic rocks that tell us they've suffered intense pressures and temperatures from overlying rocks. Hard and unfractured — how remarkable it is that the deepest part of the Hudson River cuts through them.

Resources aid building boom

Cement from our region and crushed stone that have supplied New York's building industry come from dolostones, magnesium-rich limestones north of the Highlands. New York Trap Rock at the Clinton Point quarry to this day mines this material, whose existence records the presence of a shallow sea that covered our area about 500 million years ago.

Closely associated with this carbonate rock is a shale that occurs throughout most of the Poughkeepsie area. This rock, too, is a marine sediment, akin to the material deposited in shallow offshore seaways. Though not especially rich in fossils, this rock unit, from the Ordovician period at least 435 million years ago, sometimes contains brachiopods, two-shelled marine organisms that superficially resemble but are substantially different from clams of today.

On both sides of the Hudson River in Poughkeepsie's vicinity, topographically elevated regions of the Taconic mountains to the east and the Catskill mountains to the west remain as reminders of a geologically active time in our region's past. Approximately 450 million years ago, an island chain much like Japan collided with North America and raised up the Taconic mountains. What's left of them today is their roots.

Heated and crumpled, the Ordovician shale previously laid down on the shallow sea endured a kind of pressure-cooking that turned the shale into slate, which becomes coarser-grained schist as one travels east from Poughkeepsie into Connecticut. Beautiful red garnets, elongated white needles of sillimanite, and lustrous brown staurolite crystals adorn mica schists that sparkle in the sunlight as we go east toward the Taconic mountains on the border of northeastern Dutchess County.

Not long after this, we believe that a meteor may have hit the Earth just west of the current-day Hudson River at Panther Mountain in the Catskills. There, a circular pattern six miles across is formed by the Esopus and Woodland creeks. For streams to travel in a circle is very unusual and has led some investigators to suggest the presence of an impact crater in 400-million-year-old sedimentary rock that had previously been laid down in a shallow sea.

Because sediments were being deposited in the shallow sea, the crater was buried and preserved much like a fossil. The streams have carved out a circular outline around it though the crater itself remains completely buried.

After the Taconics rose in a mountain-building event known as an orogeny, the North American continent collided with an even larger land mass farther east. This orogenic event raised up the Acadian mountains, a chain of perhaps Himalayan proportions just east of the Taconics. Sediments shed from the Acadian mountains accumulated as blankets of conglomerate, sandstone and shale in a delta. Sediments of the Catskill Delta were almost two miles thick.

Today those sedimentary strata are visible as the Shawangunk and Catskill mountains. The Devonian sandstones of the Catskill Mountains, at least 345 million years old, are what have supplied the Catskill bluestone, blue from feldspar grains in it, for curbstone and flagstones throughout the United States.

Devonian limestones forming the spectacular escarpment overlooking the Mohawk and Hudson valleys contain an abundant assemblage of life that teemed in the area's seas 345 million years ago. Stream beds cutting through the limestones at Iorio park in Vorheesville show that corals, crinoids, trilobites and brachiopods thrived during that time.

A period of quiescence followed in this area until the Atlantic Ocean began to form. The spreading of continent crust that accompanied its formation tore the crust so valleys formed. Into them poured sediments, like those which today fill the lake- and flamingo-rich valleys of east Africa.

As dinosaurs stomped atop these sediments, magma (molten rock) was injected into them. To this magma we owe thanks for the magnificent Palisades on the west side of the Hudson River. For the next 185 million years, things were quiet in our region.

The next major episode of activity reflected in our rocks is glaciation. Though glaciers began to advance on the North American continent around 2 million years ago, our area records only the most recent advance of ice.

Approximately 40,000 years ago, the last glacial advance scraped over the area's bedrock and sediments. When the ice retreated, it left behind a trail of kettle holes, moraines — sediments pushed aside like a snow plow creates drifts of snow — and glacial striations, scratch marks that we can see atop Bonticou Crag in the Mohonk Preserve of the Shawangunks in Ulster County and across the river into Millbrook in Dutchess. Perhaps most significant to valley residents, the ice carved a deep fjord which today is the Hudson River.

River forms in glacier's wake

After the ice departed, the Hudson River became Glacial Lake Albany and Glacial Lake Hudson. Influxes of clays into those lakes ultimately supplied materials for the brickyards of our area. Sediment-laden glacial meltwaters continued to course down the Hudson, across today's submarine continental shelf, and gouged out the Hudson River submarine canyon in today's New York Harbor.

Thousands of years after the valley's glaciation, humans evolved. Clearly, we have been on this planet only for a geological instant.

Despite this fact, people have managed to scar the surface of the Earth. Pits from quarry operations, PCBs (toxic industrial oils) in the bottom sediments of the Hudson River, metal-laden landfills, acidified lakes and streams each testify to that. Such transformations of natural resources affect our ability to provide what every human being deserves: clean soil, water and air.

Since we live on the eastern, passive edge of the North American continent, a place unlike the quake-plagued West Coast, we can be pretty sure that no catastrophic geologic change will occur in our area in the next millennium. But how we treat the Earth will profoundly affect our lives. We cannot afford to treat this planet as if it were an unending cornucopia of natural riches here for us to take and haphazardly discard. As we strive toward a sustainable future, we must all come to appreciate how the Earth works.

Jill S. Schneiderman is associate professor of geology at Vassar College in Poughkeepsie. She is author of ''The Earth Around Us,'' published by W.H.